



Antimicrobial Activities of the Leaf Extracts of *Ficus sycomorus* Linn. on *Helicobacter pylori* and *Citrobacter freundii*

J. O. Ihuma^{a*}, A. Z. Koggie^a, T. I. Famojuro^b, L. O. Ugboji^a and T. D. Malgwi^c

^a Department of Biological Sciences, Bingham University, P.M.B. 005, Karu, Nasarawa State, Nigeria.

^b Department of Pharmacognosy, Bingham University, P.M.B. 005, Karu, Nasarawa State, Nigeria.

^c Department of Community Medicine, Nnamdi Azikiwe University, Anambra State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author AZK designed the methodology and supervised the study. Authors JOI and LOU managed the analysis of the study and the literature of the study. Authors JOI and TDM prepared the first draft of the manuscript. Author TIF revised the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of this study is to determine the antimicrobial activities of *Ficus sycomorus* leave extract on selected bacteria. Phytochemical screening showed the presence of tannins, saponins, alkaloids and flavonoids, it also revealed the absence of glycoside.

Place and Duration of Study: Microbiology laboratory, Biological Sciences Department, Bingham University Karu, Nasarawa State, Nigeria.

Methodology: Plant extracts were prepared by boiling, soaking and methanol extraction. 96-well plates dilution method for determination of Minimum Inhibition Concentration (MIC) and Minimum Bactericidal Concentration (MBC) were carried out.

Results: The MBC for *Helicobacter pylori* and *Citrobacter freundii* showed antimicrobial activities at 400 µl each. The plant has exhibited strong antimicrobial activity on *Helicobacter pylori* and *Citrobacter freundii*.

Conclusion: The antimicrobial compounds produced by plant extracts are active against bacteria. It is expected that plant extracts showing target sites other than those used by antibiotics will be active against drug-resistant microorganisms.

*Corresponding author: E-mail: jeromeihuma@gmail.com;

Keywords: Medicinal plant; *Ficus sycomorus*; antimicrobialp; *Helicobacter pylori*; *Citrobacter freundii*.

1. INTRODUCTION

“Medicinal plants have been the basis of treatment of various diseases in African traditional medicine as well as other forms of treatment from diverse cultures of the world. About 80% of the world’s population still depends solely on traditional or herbal medicine for treatment of diseases, mostly in Africa and other developing nations. Most of the potent medicinal plants have relatively no toxic or adverse effects when used by humans, while some are very toxic to both humans and animals with the potential of damaging certain organs in the body. This calls for caution in the use of medicinal plants of which the use is presently on the increase due to easy availability, affordability, accessibility, and promising efficacy comparable to the high cost and adverse effects of standard synthetic drug agents. Several medicinal plants were evaluated for their good toxicological profile using online research. After much screening, only those medicinal plants without serious toxic effects in animals and cell culture experiments were chosen and precisely discussed” [1].

“In Nigeria, and other African countries, several roots, fruits, leaves and bark of plants are used for different medicinal purposes; some of which have been discovered in many researches to be rich in secondary metabolites like tannins, alkaloids, flavonoids, saponins, glycosides and volatile oils which are responsible for their therapeutic activities” [2].

“Traditional medicine (also known as indigenous or folk medicine) comprises medical aspects of traditional knowledge that developed over generations within various societies before the era of modern medicine. The World Health Organization (WHO) defines traditional medicine as “the sum total of the knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness.” Traditional medicine is usually contrasted with scientific medicine” [3].

“Antimicrobials – including antibiotics, antivirals, antifungals and antiparasitics – are medicines used to prevent and treat infections in humans, animals and plants” [3]. “Antimicrobial Resistance

(AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death” [3].

“As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become increasingly difficult or impossible to treat [3]. AMR occurs naturally over time, usually through genetic changes. Antimicrobial resistant organisms are found in people, animals, food, plants and the environment (in water, soil and air). They can spread from person to person or between people and animals, including from food of animal origin. The main drivers of antimicrobial resistance include the misuse and overuse of antimicrobials; lack of access to clean water, sanitation and hygiene (WASH) for both humans and animals; poor infection and disease prevention and control in health-care facilities and farms; poor access to quality, affordable medicines, vaccines and diagnostics; lack of awareness and knowledge; and lack of enforcement of legislation” [3].

“The development of bacterial resistance to presently available antibiotics has necessitated the need to search for new antibacterial agents. Gram positive bacteria such as *Staphylococcus aureus* are mainly responsible for post-operative wound infections, toxic shock syndrome, endocarditis, osteomyelitis and food poisoning” [4]. “Gram negative bacterium such as *Escherichia coli* is present in human intestine and causes lower urinary tract infection, coleocystis or septicaemia” [5]. Multiple drug resistance in human pathogenic microorganisms has been developed due to indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious diseases. The development of antibiotic resistance is multi factorial, including the specific nature of the relationship of bacteria to antibiotics, the usage of antibacterial agent, host characteristics and environmental factors.

“This situation has forced scientists to search for new antimicrobial substances from various sources as novel antimicrobial chemotherapeutic agents, but the cost of production of synthetic drugs is high and they produce adverse effects compared to plant derived drugs” [6]. “These antimicrobial substances are of natural origin, and it is thought that their influences on the

environment are few and can be used as biological control agents. However, some medicinal herbs for some reasons have not found wider application and sometimes are referred as 'forgotten plants.' Even though pharmacological industries have produced a number of new antibiotics in the last three decades, resistance to these drugs by microorganisms has increased. In general, bacteria have the genetic ability to transmit and acquire resistance to drugs, which are utilized as therapeutic agents" [7].

"*Helicobacter pylori* (*H. pylori*) infection occurs when *H. pylori* bacteria infect the stomach. This usually happens during childhood. A common cause of peptic ulcers, *H. pylori* infection may be present in more than half the people in the world. Most people don't realize they have *H. pylori* infection, because they never get sick from it. If you develop signs and symptoms of a peptic ulcer, your doctor will probably test you for *H. pylori* infection. If you have *H. pylori* infection, it can be treated with antibiotics" [8,9].

"*Citrobacter freundii* and *Citrobacter koseri* can cause urinary tract infections, and are found in wounds, respiratory organs, meningitis, and sepsis. They can cause healthcare-associated infections, especially in pediatric and immune-compromised patients" [10].

Ficus sycomorus belongs to the family *Moraceae*, it is commonly known as sand paper tree ("Baure" in Hausa) and it is widely spread in West Africa. *Ficus sycomorus* has many traditional medicinal uses in the treatment of snake bites, jaundice, chest pains, dysentery, coughs and throat infection. *Ficus sycomorus* is claimed by Jarawa people of Bauchi State to treat urinary tract infections and ulcer.

***Helicobacter pylori*:**

H. pylori, a spiral-shaped bacterium that infects roughly half the world's population, was first identified as a cause of stomach problems in the early 1980s. The discovery helped researchers link the *H. pylori* infection to conditions like gastritis, ulcers, and stomach cancer. It even paved the way for curing some stomach ulcers. Treatment for peptic ulcers depends on the cause. Usually treatment will involve killing the *H. pylori* bacterium if present, eliminating or reducing use of NSAIDs if possible, and helping the ulcer to heal with medication. Antibiotic medications to kill *H. pylori*. If *H. pylori* is found in

your digestive tract, your doctor may recommend a combination of antibiotics to kill the bacterium [11,12].

Treatment for peptic ulcers depends on the cause. Usually treatment will involve killing the *H. pylori* bacterium if present, eliminating or reducing use of NSAIDs if possible, and helping the ulcer to heal with medication. Antibiotic medications to kill *H. pylori*. If *H. pylori* is found in your digestive tract, your doctor may recommend a combination of antibiotics to kill the bacterium [13,14].

***Citrobacter freundii*:**

C. freundii is a soil organism, but can also be found in water, sewage, food and in the intestinal tracts of animals and humans [15]. The bacteria that cause urinary tract infections typically enter the bladder via the urethra. However, infection may also occur via the blood or lymph. It is believed that the bacteria are usually transmitted to the urethra from the bowel, with females at greater risk due to their anatomy [16]. After gaining entry to the bladder, *C. freundii* are able to attach to the bladder wall and form a biofilm that resists the body's immune response [16].

The mainstay of treatment is antibiotics. U.T.I.s are one of the world's most common infections, but many of the drugs used to treat them have become less effective as resistance to antibiotics grows. The majority of urinary tract infections are now resistant to one or more antibiotics. The drug ampicillin, once a common treatment, has been largely abandoned because most U.T.I.s are now resistant to it [17].

1.1 Purpose of the Study

The significance of this study is to discover the phytochemical properties of the plant *Ficus sycomorus* and also check the antimicrobial activity on microorganisms that cause infections.

The research will also provide a cheaper readily available alternative to antibiotics for the treatment of diseases caused by microorganisms and also open the eye of researchers to the potential of the plant ficus. If the research is successful, it will provide a cost effective treatment for people in underdeveloped areas where access to antibiotics is hard, people living with poverty and the population at large.

2. MATERIALS AND METHODS

2.1 Area of Study

The laboratory work was carried out in the Microbiology laboratory, Biological Sciences Department, Bingham University Karu, Nasarawa State. Bingham University is approximately 25km from the Federal Capital Territory (FCT), Abuja. Bingham University is located at longitude 7.6° E and latitude 8.9° N in Karu, Nasarawa State, Nigeria [18]. Fresh leaves of *Ficus sycomorus* were obtained at a forest near Babele, Plateau State of Nigeria and were taken to the Botany Department of Federal College of Forestry, Jos, for identification. The fresh leaves of *Ficus sycomorus* were rinsed with distilled water and dried at room temperature for fourteen days. The dried sample was then crushed into powdery form using mortar and pestle and was blended with USHA Mixer Grinder, MG2053N and stored in polythene bags for analysis.

2.2 Preparation of Plant Extracts

Three different extracts were prepared - hot water extract according to the local method, cold water extract and methanol extract. Both hot and cold-water extraction were made. 200g of the powdered leaves was dissolved into 1000 ml of distilled water, and allowed to boil for 15 minutes; it was then left to stand for about 6 hours to ensure maximum extraction of nutrients. The mixture was sieved using a sterile sieve. The filtrate was subjected to drying in a hot air oven at 55°C to obtain the extracts in solid forms and were stored in air tight sterile containers with each fully labeled. Same gram of the powdered leaves was weighed into a sterile jar and mixed with 1000ml of cold water; it was left to stand for 24 hours at room temperature to allow for maximum extraction. It was filtered using a sterile sieve. The filtrate was subjected to drying in a hot air oven at 55°C to obtain the extracts in solid forms and were stored in air tight sterile containers with each fully labeled.

2.3 Methanol Extraction

A weighed portion of powdered material was extracted by cold maceration in 1000 ml of methanol and shaken intermittently for 72 hours then filtered with a sterile sieve and also through a Whatman Filter paper [19]. The rotary evaporator was used to separate the solvent from the extract. The solid extract was stored in

an airtight sterile container until further analysis. The extracts of the plant samples were screened for alkaloids, saponins, tannins, glycosides and flavonoids according to the method of Sofowora [20].

2.4 Source of Bacterial Isolates

The pure bacterial isolate of *Helicobacter pylori* and *Citrobacter freundii* were obtained from the bacteriology division of the National Veterinary Research Institute, (NVRI) Vom and Bacteriology Laboratory, Federal College of Veterinary and Medical Laboratory Technology Vom. Purity plates of each of the isolates were obtained by sub-culturing the isolates unto appropriate media and biochemical tests were performed to confirm their identity.

2.5 Preparation of Mcfarland Turbidity Standard

Barium sulphate suspension at 1.0% w/v was prepared as follows: One percent (1% w/v) solution of sulphuric acid was prepared by adding 1ml of concentrated H₂SO₄ in 99 ml of water. One percent (1% w/v) solution of barium chloride was also prepared by dissolving 0.5g of barium chloride in 50ml of distilled water. Barium chloride solution (0.6 ml) was added to 99ml of sulphuric acid solution given Mcfarland standard (0.5) an equivalent density of 1×10⁸ cfu/ml of turbidity.

2.6 Preparation of Dilution of Different Extracts

0.8 g of the hot, cold and methanolic extracts were dissolved in 8ml of Dimethylsulfoxide (DmSO₄) respectively to give a stock solution of 400mg/ml, doubling dilution was then carried out to give concentrations of 200 mg/ml, 100mg/ml, 50mg/ml and 25 mg/ml. The test control was prepared using 500 mg amoxicillin. The drug was dissolved in 10 ml of distilled water.

2.7 Determination of Minimal Inhibitory Concentration (MIC)

The minimum inhibitory concentration (MIC) for plant extract was evaluated according to the method described by the minor modification of employing 96 well microtitre plates [21]. For each 100µl of MHB was placed to each well followed by 100µl of plant extract (which contains 400mg/ml of plant extract) added to the first column of the microtiter plates. This made each

well of the first column to have a total volume of 200 μ l. Starting from the first column serial dilution was conducted up to the 10th column with double folding; the final volume (3.125 μ l) of the plant extract and the broth were drawn from the 10th column and the last dilution was discarded. In the negative control column, 30 μ l of 2% Dm SO₄ was dispensed in the well plates. Bacterial isolate added to normal saline was compared with Mcfarland turbidity standard and dispensed at 50 μ l into the wells up to 10th column aseptically. 50 μ l of amoxicillin was added to the positive control. Subsequently, the plates were wrapped with foil paper and incubated for 24 hours at 37°C in the incubator. The minimum inhibitory concentration (MIC) was determined by adding 30 μ l (2mg/ml) of 0.02% resazurin dye and incubated at 37°C for one hour. Resazurin dye was used as an indicator for bacteria growth; bacteria metabolize it and change into pink colour. The wells that had no change in colour after the addition of resazurin dye indicated no growth of the microorganisms and they were taken as MIC values using 96 well microtiter plate method.

2.8 Determination of Minimal Bactericidal Concentration (MBC)

The Minimal Bactericidal Concentration (MBC) is defined as the lowest concentration where no bacterial growth is observed. This was determined by aseptically sub-culturing the contents of wells with the lowest inhibition from the MIC results for individual bacterium

concentration (MBC) on Mueller Hilton agar. The plates were incubated for 48 hours after which it was observed if growth was present [22].

3. RESULTS AND DISCUSSION

The Analysis of Variance (ANOVA) was used as a statistical method to test the hypothesis. Phytochemical analysis was conducted on the aqueous and methanol extracts of *Ficus sycomorus* and the following results were obtained and recorded. The phytochemical analysis of *Ficus sycomorus* showed that the extract contains excessively high presence of saponins, high presence of alkaloids and tannins, presence of flavonoids, and absence of glycosides.

Table 2 shows the MIC values of the extracts against *Helicobacter pylori* and *Citrobacter freundii* which showed antimicrobial activity. The activities recorded were that of *Ficus sycomorus* extracts (boiled, soaked and methanol) against *Helicobacter pylori* and *Citrobacter freundii*, the MIC values were determined at the lowest concentrations of the plant extracts that showed inhibition against microorganisms.

MBC values of the plant extracts against *Helicobacter pylori* and *Citrobacter freundii* were 400 μ l/ml each, for both boiled, soaked and methanol extracts, this shows that higher concentrations of the plant extracts are needed to show antimicrobial activity.

Table 1. Results of qualitative phytochemical analysis of *Ficus sycomorus* extracts

Phytochemicals	Status	Degree of occurrence
Alkaloids	Present	++
Tannins	Present	++
Glycosides	Absent	-
Saponins	Present	+++
Flavonoids	Present	+

Key: - = Absent; + = Present; ++ = Highly present; +++ = Excessively present

Table 2. Results of minimum inhibitory concentrations (MIC) of *Ficus sycomorus* against selected Bacteria

Extract	Concentration of organisms (μ l/ml)	
	<i>H. pylori</i>	<i>C. freundii</i>
Boiled	12.50	3.125
Soaked	25.00	3.125
Methanol	3.125	25.00

Table 3. Results of minimum bactericidal concentration (MBC) of *Ficus sycomorus* against selected bacteria

Extract	Concentration of organisms (ul/ml)	
	<i>H. pylori</i>	<i>C. freundii</i>
Boiled	400	400
Soaked	400	400
Methanol	400	400

3.1 Discussion

From Table 1 the qualitative analysis of the phytochemical constituents of the plant extract of *Ficus sycomorus* revealed the presence of saponins, alkaloids, tannins and flavonoids, it also revealed the absence of glycosides. This shows excessively high presence of saponins, alkaloids and tannins were highly present, flavonoids were present. The analysis also revealed the absence of glycosides. The result from the study of antifungal activity and phytochemical analysis of *Ficus sycomorus* leaf extracts on *Malassezia glubosa* showed the excessively high presence of tannins, glycoside and alkaloids while saponins and flavonoid were highly present [16]. These compounds are known to exhibit great antibacterial activities. The presence of these phytochemicals gives the plant its antimicrobial property. These phytochemicals according to Adeshina, [23] are the chemical compounds synthesized by plants to ensure therapeutic effects.

From Table 2 the result observed shows the MIC values of the extracts against *H. pylori* and *C. freundii* which showed antimicrobial activity. The activities recorded were that of *Ficus sycomorus* extracts (boiled, soaked and methanol) against *H. pylori* and *C. freundii*, the MIC values were determined at the lowest concentrations of the plant extracts that showed inhibition against microorganisms. The MIC values of *H. pylori* for soaked extract was 25 µl/ml, which showed inhibition at high concentration, followed by the boiled extract 12.5 µl and methanol extracts was 3.125µl/ml which is the lowest. For *C. freundii* for methanol extract was 25µl/ml, which showed inhibition at high concentration, soaked and boiled extract were 3.125µl/ml each. This shows that all three plant extracts are effective against the bacteria just as in because even at the least concentration from the research work of 10mg/ml, zone of inhibition of 40mm was recorded and noted down [24].

In this study, MBC values of the plant extracts against *Helicobacter pylori* and *Citrobacter*

freundii were 400µl/ml each, for both boiled, soaked and methanol extracts, this shows that higher concentrations of the plant extracts are needed to show antimicrobial activity.

The values of the MIC and MBC of *Ficus sycomorus* were 1.95, 31.3 and 3.91, 250mg/ml, respectively. Similarly, *F. platyphylla* displayed 1.95 and 7.8mg/ml MIC values and 3.91 to 62.5mg/ml MBC values agents test organisms which were; *staphylococcus aureus* and *salmonella typhi*. The observed antibacterial activities in this study proved that the leaves and stem bark extracts of *Ficus spp* obtained in Zaria support the folkloric claims of the use of *Ficus* plants in the treatment of ailment such as wound dressing [23].

From the ANOVA analysis, we had a P value of $P > 0.05$. A p-value less than 0.05 indicates that there is a significant difference between MIC and MBC of the different plant extracts used, if it is greater than 0.05, there is no significant difference. However, there was no significant difference observed in the reactions of the bacterial populations examined with respect to method of extraction used for both MIC and MBC. The null hypothesis which states that the plant showed no antimicrobial property against the test organism is rejected and we accept the alternate hypothesis which states that the plant showed antimicrobial property against the test organism.

4. CONCLUSION

Ficus sycomorus has for a very long time been used traditionally as a medicinal treatment of different ailments to replace antibiotics. This research focused on finding the scientific backing for claims of its healing property. The antimicrobial activity has been determined on certain drug resistant pathogenic microorganisms. The plant has shown to exhibit strong antimicrobial activity on *H. pylori* and *C. freundii*. The phytochemicals are also active to prevent bacterial growth without giving cognizance to method of extraction of the extract.

5. RECOMMENDATIONS

1. Based on the result from this study *Ficus sycomorus* has been proved to contain antimicrobial properties, it is a widely distributed plant which is easily affordable, therefore it should be further exploited as a means of treatment for drug resistant microorganisms.
2. Further research should be done to determine the toxicity and dosage of *Ficus sycomorus* for effective administration which can reduce unwarranted side effects.
3. A further study to isolate substances and use them in microbial action tests.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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